

FIRE HISTORY ON THE IDAHO PANHANDLE NATIONAL FOREST

by

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REVIEW DRAFT

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CONTENTS

	Page
EXECUTIVE SUMMARY	1
INTRODUCTION	
Background	3
Study Area	3
Fire As An Ecosystem Process	5
Literature Review	6
METHODS	
Field Methods	10
Data Analysis	
Data Base Construction and Assigning Fire Dates	15
Precision in Estimating Fire Dates	18
Fire Severities and Fire Regimes	19
Calculating Mean Fire Return Intervals	22
RESULTS	
Fire Return Intervals	24
Fire Size	30
DISCUSSION	31
Variability in Fire Severity	32
Spatial Variability	33
Temporal Variability	34
Climatic Patterns Through Time	36
Fire Regimes and Landscape Vegetation Patterns	40
REFERENCES	43

EXECUTIVE SUMMARY

This paper reports results of fire history studies on two forested landscapes in northern Idaho: the 570,000 acre North Fork Coeur d'Alene River Basin, and 230,000 acres of mountainous watersheds north of Bonners Ferry. Both areas are dominated by moist forested habitat types typical of areas with an inland maritime climate.

Data was gathered on large variable sized plots of from two to seven acres. The majority of the data comes from tree ring counts of tree origin and fire scar dates, supplemented by similar counts on increment cores.

The Coeur d'Alene study covers the period 1540 to 1992, and reports a variable fire regime of long return interval large lethal (stand replacing) fires mixed with shorter return interval nonlethal and mixed severity fires. The specific return intervals varied by geographic area. Fires were more frequent in watersheds on the periphery of the Coeur d'Alene Basin, adjacent to and downwind from the drier pine dominated Rathdrum Prairie. Viewed from the spatial scale of small stands, in these peripheral watersheds the mean lethal (stand replacing) fire return interval is 138 years, and the mean return interval for all fires (including nonlethal and mixed severity) is 62 years. The interior of the North Fork of the Coeur d'Alene forms a buffered enclosed basin dominated by western hemlock (*Tsuga heterophylla*) habitat types. Here, the small stand mean fire return interval for lethal fires is 203 years, and the mean return interval for all fires (including non lethal and mixed severity) is 84 years.

Results are strongly scale dependent. From the landscape perspective, between 1540 and 1931 there was an average of one major (affecting 5%+ of the plots) fire episode every 19 years, somewhere in the 570,000 Coeur d'Alene study area. None of these fire episodes burned a majority of the river basin, but some burned areas of several tens of thousands of acres -- or larger. Landscape scale fire frequency varied over time. Since 1931 we did not record any major fire episodes. Between 1878 and 1931 there was an average of one major fire episode every eight years somewhere in the 570,000 acre study area. Between 1764 and 1878 there was an average of one major fire episode every 13 years somewhere in the study area. Between 1540 and 1764 there was an average of one major fire episode every 56 years somewhere in the study area. The magnitude of difference in these numbers is exaggerated by the limitations of the

study methodology. However, the changes of frequency appear at abrupt time boundaries, and appear to represent real differences in fire frequency over time. Correlations with major fire events identified in other fire history studies across the northern Rocky Mountains suggests a link to regional climate shifts.

Fire return intervals and severities are quite variable on all scales. This variability is as important as the mean values in understanding the effects of fire on landscape vegetation structure and pattern. Management that simply used mean return intervals of lethal fires as a basis of timber harvest rotations would fail to capture much of the diversity created by these historical fire regimes. Both lethal and lower severity fire contribute to vegetative diversity at the landscape level. Variation around the mean return intervals implies that both old growth and shrub-dominated early seral stages likely existed in greater proportions than would be suggested from simply examining the mean lethal fire return interval.

INTRODUCTION

Background

The U. S. Forest Service has decided to base its land management on the principles of Ecosystem Management. With ecosystem management there is a major focus on the state and functioning of the ecosystem as a whole. Knowledge of the historical range of variability in ecosystem functions and structures provides a tool useful in understanding the patterns and processes we observe. The historical range of variability also provides a reference to help assess the effects of proposed actions. Wildfire is a keystone disturbance process in many ecosystems. Understanding the role of fire helps provide an understanding of the historical range of variability.

The objective of this study is to produce a preliminary picture of forest wildfire regimes on two areas of the Idaho Panhandle National Forest. The two areas are: (1) the North Fork and Little North Fork of the Coeur d'Alene River and adjacent smaller watersheds that drain directly onto the Rathdrum Prairie or Lake Coeur d'Alene; and (2) the Selkirk Mountains west and north of Bonners Ferry, Idaho, and the western part of the Purcell Mountain north of Bonners Ferry. The major emphasis will be to examine the question of fire return intervals.

Study Area

Northern Idaho has an inland maritime climate. The inland northwestern United States is in the rain shadow of the Cascade Mountains and most areas have a largely dry continental climate with relatively cold winters and hot very dry summers. However, northern Idaho sits is an island of moisture in this region. An inland maritime airflow strongly influences the mountains of northern Idaho gives it (and adjacent areas of British Columbia, extreme northeastern Washington and northwestern Montana) much greater precipitation and more moderate temperatures than any of the surrounding area. The influence of this moist inland airflow is strongly seasonal, giving northern Idaho wet snowy winters and much drier warmer summers.

Deception Creek Experimental Forest is a typical 3100 foot elevation site in the interior of this study area. Its 1931 to 1980 average weather is as follows (Finklin and Fischer 1987):

Mean Annual Precip (inches)	July Mean Precip (inches)	Dec. Mean Precip (inches)	Annual Temp (° F)	July Temp (° F)	Jan. Temp (° F)
55.8	1.0	8.9	41.8 mean 53.3 max 30.3 min	61.9 mean 80.6 max 43.2 min	22.6 mean 28.8 max 16.4 min

These are mountainous areas. Elevations in the Coeur d'Alene study area vary from 2300 feet to 6000 feet, with the majority of sites between 3100 and 4500 feet. The lower and mid elevations of these moist inland maritime region are dominated by western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*) plant associations at mid elevations; grand fir (*Abies grandis*) plant association are often found on drier aspects and landforms. The upper elevations are dominated by subalpine fir (*Abies lasiocarpa*) and mountain hemlock (*Tsuga heterophylla*) plant associations (although in the Coeur d'Alene study area elevations are low enough that there is only a minor fringe of these subalpine types at the tops of the highest ridges and along the Bitterroot Divide). Western hemlock habitat types so dominate the landscape in the Coeur d'Alene Basin that it could really be characterized as a hemlock ecosystem. The Coeur d'Alene River Basin is the heart of the interior western hemlock ecosystem in the United States.

Soils throughout the study area have a surface layer of volcanic ash, largely resulting from the Mount Manzama eruption. Ash depths average 14 inches at mid elevation sites in the Coeur d'Alene, although this is quite variable. Underlying residual soils in the Coeur d'Alene Basin are largely derived from belt series rocks, with some minor areas of granitics.

Fire as an Ecosystem Process

Vegetation is a fundamental part of terrestrial ecosystems. Vegetation is a basic element of wildlife habitat and is a critical factor regulating hydrologic regimes. The vegetation structures that exist across an ecosystem and through time are a function of climate, the physical site, the plant species available in an area, the disturbance history of the site, and the successional processes that follow disturbance. Sites with only climax vegetation are rare. Most landscapes are a mosaic reflecting the interaction between disturbance history and plant succession. The interaction between disturbance forces and successional processes is a keystone process shaping the landscape vegetation mosaic. Understanding disturbance regimes is necessary to understand the vegetation.

Forests can be disturbed by weather (windstorms, ice storms, and extreme droughts and cold periods), by insects, and by micro-organisms. All of these disturbance forces interact with fire. However, the amount of energy that fire can release in short periods of time -- and the dramatic effects of that energy upon the vegetation -- make it one of nature's most powerful disturbance forces.

In the western United States, wildfire is a keystone disturbance process. Most of the western United States experiences significant summer dry periods when vegetation can sustain wildfires. Lightning is a common ignition source in Northern Rocky Mountains ecosystems, with a frequency sufficient to explain a relatively high occurrence of wildfire (see Table 1 below). In the valleys adjacent to these study areas, Native Americans lived year round. In the periphery of these study areas Native American use of fire may have been a significant ignition source for much of the Holocene. However, in the mountainous interior of these study areas Native American use was only seasonal and short term. In these interior areas lightning was probably the primary ignition source prior to Euro-American settlement.

Table 1 -- Lightning fire frequency (Barrows and others 1977)

LIGHTNING FIRES IN NORTHERN IDAHO -- 1946-1973		
	Coeur d'Alene National Forest	Kaniksu National Forest
Total number lightning fires: 1946-1973	1131	1845
Average annual number of lightning fires	40.4	65.9
Average annual number of lightning fires per million acres	55.9	42.8
Annual high number of lightning fires & year	115 (in 1947)	165 (in 1961)
Annual low number of lightning fires & year	4 (in 1969)	18 (in 1959)

Literature Review

In many of the open dry ponderosa pine forests surrounding our study area there is a well documented fire history of frequent (fire return intervals of a few years to three or four decades) nonlethal understory fires (Agee 1993; Arno 1976; Arno 1980; Losensky 1993). On the other hand, just west of the Washington Cascade Mountains, in the wet coastal climatic zone, Douglas-fir, western hemlock, western redcedar, and Pacific silver fir forests have far fewer fires. In those maritime temperate forests the fire regime is dominated by infrequent (fire return interval of centuries) large and severe stand replacing fires (Hemstrom 1979; Agee 1993). Northern Idaho sits in the midst of the dry inland region, but it has a strong inland maritime climatic influence and plant associations similar to some found along the coast. We wanted to characterize the fire regimes of these moist inland forests.

It's only in the last 15 years that there has been significant fire history research in the inland moist forests of the Northern Rocky Mountains. What has been discovered is summarized in Table 2, below. Most of this work has been on the southern or eastern periphery of this inland maritime zone, and many of these studies are outside of the range of western hemlock. The Idaho Panhandle National Forest, which is the heart of the interior moist hemlock, has still had very little fire research. The intent of this study is to begin characterizing the fire regimes of the moist inland maritime forest ecosystems in the Idaho Panhandle.

Table 2 -- literature summary of fire history research on moist habitat types in the Northern Rocky Mountains.

[2.1]					MEAN FIRE RETURN INTERVAL (& RANGE)			
LOCATION	AUTHORS AND DATE	COVER TYPE	HABITAT TYPE	LANDSCAPE POSITION	ALL FIRES	UNDERBURN	LETHAL FIRES ONLY	FIRE REGIMES & COMMENTS
Swan Valley, MT	Antos & Shearer 1980	various mixes -- not clearly differentiated as to fire regime	ABGR/CLUN THPL/CLUN	broad valley & adjacent lower slopes	--		150 yrs (<20-300 yrs)	mixed & nonlethal fires are evident in this area, but not discussed in this publication
Cook Mountain, Clearwater NF, ID	Barrett 1982		THPL/PAMY	north aspect & lower slopes & riparian	48 yrs $\pm$ 20 (24-77 yrs)			only included large (1,000+ ac fires) -- probably variable regime
Cook Mountain, Clearwater NF, ID	Barrett 1982		ABGR/PAMY	variety of aspects & slope positions	29 yrs $\pm$ 11 (19-46 yrs)			only included large (1,000+ ac fires) -- probably variable regime
Priest River Basin, ID	Arno and Davis 1980	predominantly old growth cedar with some hemlock	THPL/ATFI THPL/OPHO	riparian and very moist benches	>200 yrs			predominantly low intensity nonlethal fires; lethal fires rare
Priest River Basin, ID	Arno and Davis 1980	mesic northern Idaho mixed conifer	THPL/PAMY TSHE/PAMY	lower and middle slopes	50 - 150 yrs			variable severity fire regimes with lots of topographic control
Dromedary Area; Superior Ranger Dist.; Lolo Nf	Barrett 1991	cedar and grand fir	moist THPL	bottoms & moist ravines			150 - 250 yrs	this habitat type only occupies most moist part of this landscape; mostly stand replacing fire

[2.2]					MEAN FIRE RETURN INTERVAL (& RANGE)			
LOCATION	AUTHORS AND DATE	COVER TYPE	HABITAT TYPE	LANDSCAPE POSITION	ALL FIRES	UNDERBURN	LETHAL FIRES ONLY	FIRE REGIMES & COMMENTS
Selway-Bitterroot Wilderness, ID & MT	Barrett and Arno 1991	ponderosa pine/ Douglas- fir	ABGR/PHMA PSME/PHMA PSME/SYAL	warm aspects-- landscape mosaic predominantly drier H.T.'s		23 yrs		nonlethal underburns w/ occasional lethal/nonuniform
Selway-Bitterroot Wilderness, ID & MT	Barrett and Arno 1991	shrubfield- conifer (area of multiple burns & persistent shrubfields)	ABGR/PHMA PSME/PHMA	warm aspects -- landscape mosaic includes DF H.T. 's			30-60 yrs	predominantly lethal fires/uniform burns
Selway-Bitterroot Wilderness, ID & MT	Barrett and Arno 1991	DF/GF	ABGR/ASCA ABGR/CLUN ABGR/LIBO	cooler aspects		50-100 yrs	119 yrs	mixture of lethal/uniform and mixed/nonuniform
Selway-Bitterroot Wilderness, ID & MT	Barrett and Arno 1991	cedar	THPL/CLUN THPL/ATFI THPL/ASCA	moist aspects & riparian strips			197 yrs	lethal/nonuniform
N. Fork Clearwater River, ID	Barrett 1993	old growth cedar	THPL/ADPE THPL/ATFI	moist bottoms & draws		93 yrs (24-200)	291 yrs (200-430+)	

[2.3]					MEAN FIRE RETURN INTERVAL (& RANGE)			
LOCATION	AUTHORS AND DATE	COVER TYPE	HABITAT TYPE	LANDSCAPE POSITION	ALL FIRES	UNDERBURN	LETHAL FIRES ONLY	FIRE REGIMES & COMMENTS
N. Fork Clearwater River, ID	Barrett 1993	mature sawtimber DF/DG/mixed conifer	THPLC/ASCA THPL/CLUN ABGR/ASCA ABGR/CLUM	upland slopes		107 yrs (42-186)	216 yrs (109-363+)	underburns may be burn margin effect
N. Fork Clearwater River, ID	Barrett 1993	PP/DF/GF	ABGR/PHMA ABGR/CLUN ABGR/XETE/	upland slopes- on a variety of aspects	34 yrs (17-57)			predominantly mixed severity and nonlethal fires
N. Fork Coeur d'Alene River, ID	Zack and Morgan 1994 (this study -- included for comparison)	mesic northern Idaho mixed conifer	predominantly TSHE series with ABGR series on drier aspects; TSHE/CLUN most common	a variety of slope positions and aspects in Coeur d'Alene basin	~~84~~ yrs ± 45 (4-322)		~~203~~ yrs ± 82 (18-452)	interior of moist river basin -- variable fire regime: long interval, large stand replacing fires & double burns with shorter interval mixed severity underburns
Hayden Lake watershed, ID -- adjacent to Rathdrum Prairie	Zack and Morgan 1994 (this study -- included for comparison)	mesic northern Idaho mixed conifer	predominantly TSHE & THPL series mixed with ABGR series on drier aspects and a few DF sites	a variety of slope positions & aspects one drainage west of the N. Fork Coeur d'Alene River	62 yrs ± 31		~~144~~ yrs ± 51 138	similar habitat types & landforms to above, but this slope & watershed is immediately adjacent to large valley dominated by drier habitat types

METHODS

Field Methods

Many of the classic fire history studies in the northern Rocky Mountains have relied heavily on multiple fire scars analyzed from wedges cut out of old trees -- predominantly ponderosa pine (Arno 1976; Arno 1980; Arno and Sneck 1977). Fire scarred wedges (or occasionally increment cores with scars) are transported back to the laboratory, sanded, and rings to fire scars and to the pith are carefully counted under magnification. This allows quite precise dating of individual records, but is very time intensive.

While the above methodology works well in drier regions, it is less suited to the moist forests of northern Idaho. The local history of large stand replacing fires means that trees with multiple fire scars are rare. High precipitation leads to three particular problems. First, trees grow to large diameters, which makes cutting and transporting wedges difficult and time consuming. Second, high precipitation coupled with relatively mild temperatures means that damaged trees and stumps rot quickly. Rot proceeds so quickly that even when a fire scarred tree can be found, it's likely to be too rotten to produce a wedge sound enough for transport. Very often, a stump with a surface sound enough to count rings would be rotten below and colonized with ants. Third, in these moist ecosystems, ponderosa pine (the best species for recording multiple fire scars) is relatively rare and only grows on a narrow range of sites. Finally, in much of northern Idaho, starting as early as the 1890's -- but particularly since 1960 -- there has been a history of heavy timber harvest, concentrating on stands with larger (and older) trees. Much of the evidence of older age classes and older fire events has been reduced to decaying stumps. These decaying stumps may provide the last best chance to establish a long term record of historical fire regimes across this moist ecosystem.

For all of the above reasons, this study employed some unique methods. This is an extensive rather than intensive study. We relied on field data rather than precise laboratory work. Our main emphasis was on fire return intervals. We felt that averages generated from large amounts of carefully collected field data over a relatively big area would enable us to get a good picture of average fire return intervals.

Tree origin and fire scar dates were determined from field counts of tree rings, concentrating on stumps wherever they were available, and using increment cores only

when stumps were not available. All counts were done with the aid of either 10 or 14 power handlenses. Hatchets were available to scrape stump surfaces clean and enhance the visibility of rings. During the second summer of sampling, field crews also had a chain saw to cut a fresh stump surface. However, because the amount of decay and frequency of ant colonization common in stumps, this tool was only useful in a small minority of circumstances.

Stumps are easier and quicker to count than drilling increment cores. Scar dates obtained from stumps are more accurate. If there is rot in the tree, on a stump face it is often possible to work around the rot and still get accurate ring counts. In the course of field sampling, we also observed that earlywood and latewood in the tree rings decay at different rates. Often, a partially decayed stump would have lost much of the earlywood in the rings on the stump surface, but the denser latewood was still clearly visible. With these partially decayed stumps the rings were clearly visible and relatively easy to count.

Some burned stumps, or older decaying stumps, may be missing a small part of the wood around the outside edge. Likewise, many fire scarred trees may have rot in the middle, where it isn't possible to count the rings. In both cases, inability to accurately estimate how many rings may be missing here does introduce some noise to the data. We did not generally sample trees that only had a small ring of countable rings, and huge hollow areas in the center. This meant that many of the oldest redcedar in these forests were not included in this study.

Because of the known history of large stand replacing fires in northern Idaho, we were concerned about bias resulting from sampling a single watershed, where the last major stand replacing fire episode might unduly influence the results. For that reason, we consciously scattered our study across a number of different watersheds with apparently different recent fire histories. The intent was to obtain samples that would allow us to characterize both a landscape-wide average fire regime and individual watershed fire histories. We could then use the watershed differences to examine the range of variability across the landscape and through time.

Plots were not evenly distributed within the larger study areas, but are concentrated in a relatively small number of sample watersheds. In both the North Fork Coeur d'Alene River Basin (approximately 570,000 acres in our broad sample area) and the Selkirk

Mountains (approximately 230,000 acres in our broad sample area) , several watersheds of 5,000 to 25,000 acres were selected for sampling. In each of these sample watersheds the field crew scattered plots throughout the drainage, sampling a full variety of the aspects and slope positions represented. Where the topography allowed, the field crew leader would pre-select three or more transects (at least one each in the upper, middle, and lower ends of the watershed), and pre-locate approximate areas for an upper slope, mid slope, and lower slope plot on each side of the watershed. When going to the field, the crew would locate the pre-selected sample area, and then search for a nearby timber harvest site with stumps available for ring counts. Within harvest units, the field crew searched for sites that had trees with fire scars, or appeared to have remnants of an older residual age class that had survived one or more fire. Where no nearby harvest sites were available, the plot would be located in a representative intact stand.

Some bias in plot location may have been introduced by attempting to locate plots in areas with residual or fire scarred trees that survived one or more fires. However, these residual trees were necessary to obtain records of intervals between fires. Over the course of field sampling, it became obvious that stands with at least a remnant of more than one age class were much more common than originally anticipated, and the introduction of bias became less of a concern. Even in stands that are normally classified as even-aged, it is frequently possible to find scattered individual trees or small patches of trees that survived the last fire.

Field sampling was carried out during the summers of 1992 and 1993 by a two person field crew. The crew leader for both summers was the same very experienced individual. Tree records were gathered from plot sampling (146 plots on the Coeur d'Alene study and 66 plots on the Bonners Ferry study). During 1992 approximately 1500 tree records (average 10.3 trees per plot) were gathered in the North Fork Coeur d'Alene River Basin and adjacent small drainages. During 1993, 1186 tree records (average 18.0 trees per plot) were gathered in the Bonners Ferry area -- mostly in the Selkirk Mountains.

On each plot, the goal was to obtain three or more age/scar samples of trees in each age/size class greater than five inches DBH for each species. There was no fixed plot size for the age/scar samples. The field crew was instructed to go as far from plot center as necessary to obtain the desired samples, so long as they were still within

the stand structural type and did significantly change aspect, slope shape, or landform. Trees recorded were generally within 100 to 200 feet of plot center, but, some were 300+ feet away. A 200 foot radius circle is equal to 2.88 acres in area. A 300 foot radius circle is equal to 6.49 acres in area. These plots are considered a stand level sample of the range of age classes available. The sample trees do not constitute a representative stand sample of frequency of fire scarred trees or age classes. Rather, this is a sample aimed at obtaining the longest possible tree ring record of stand fire history.

On each plot the field crew would first locate and mark a plot center, and then record three sets of information:

- (1) Site data including location (in the second field season this included GPS location), habitat type, slope, aspect, elevation, slope position, slope shape (landtypes and additional details about landform and geology were filled in later the Idaho Panhandle National Forest soils scientists, based on the topographic map plot locations), and known disturbance history (from both site observation and records in the Idaho Panhandle National Forest Timber Stand Management Record System [TSMRS]). Plot center was marked on a 1:24,000 scale topographic map.

- (2) On a 1/10th acre circular plot, they tallied all live trees by species and size class (no attempt was made to reconstruct the previous stand if it had been harvested). The first season, the crew also estimated cover and height of all vascular plant species with 5% or greater cover using a 1/10th acre ECODATA Plant Composition plot. This Plant Composition plot was abandoned part way though the second sampling season, in order to gain more time to gather age class and fire scar data.

- (3) The most important data were tree ring counts of age and fire scar dates on the 1/10th acre plot and in the surrounding area. The majority of tree records were gathered from stump surfaces in stands harvested between one and 30 years ago. When stumps were not available, origin and scar dates were gathered by increment boring. The tree records include tree species, diameter, ring count to the tree pith, and ring count to all fire scars. Approximately 22% of the trees in the Coeur d'Alene sample have at least one fire scar, although only 4% of the trees have two or more scars.

The field crew was instructed in distinguishing fire scars from other tree scars of non-fire origin. Charcoal associated with the scar was considered proof of a fire. However, many fire scars representing a single fire will not have any charcoal associated. The crew was instructed to look for a pattern of scars on the plot all being on the same side of the tree (usually the uphill side) as evidence of fire origin. Fire scars will also usually extend to the ground line, where other types of scars may be higher in the tree. Correlation with tree origin dates of a seral tree species age class was also considered evidence of fire origin. Larch, in particular, is dependent upon fire to prepare a seedbed. Scars on thin barked species were considered more suspicious because of their susceptibility to mechanical damage. Here, correlation with other trees was used to corroborate fire origin. Fallen rotten logs on the same side of the tree as the scar was considered evidence of mechanical damage. Where scars were clearly not of fire origin, they were not recorded. Where fire origin was questionable, the scar was recorded, but the plot notes described the reason for questioning the cause.

For each plot, the field crew recorded some brief notes describing the plot and its surroundings and any apparent fire-related patterns of age classes or scars. After each watershed was completed, the field crew also recorded a watershed narrative describing the general fire related patterns that were observed.

The Coeur d'Alene sampling was scattered across ten different watersheds. In seven of these watersheds we had 14 or more plots, well enough distributed to meaningfully characterize the watershed fire regime. In the other three watersheds there were either too few plots, or they were not well enough distributed to characterize the watershed. However, these scattered plots did contribute to the larger river basin and area statistics.

In the Coeur d'Alene study we distributed 146 plots across 93,080 acres (37,668 ha) of sample watersheds and partial watersheds. This is approximately 16% of the 570,000 acre (231,000 ha) river basin. The average sampling density worked out to 1 plot per 638 acres (1 plot/258 ha), or approximately 1 plot per square mile (1 plot/2.59 km²). On a tree basis, our 1500 sample trees created a sampling density of 1 tree per 62 acres (1 tree/25 ha), or approximately 10.3 trees per square mile (4.0 trees/km²).

Data Analysis

Data Base Construction and Assigning Fire Dates

Tree ring counts to fire scars and to the tree pith were converted to calendar dates. Ring counts were adjusted to allow for the time it took the tree to grow to the height above ground where the ring count was taken and the time since stumps were cut. The following Table 3 was used to standardize the age adjustments for sampling height.

Table 3 Estimated average time, by genus, to grow to specified height where rings were counted (stump surface height or height where increment bored)

height	0.5'	1.0'	1.5'	2.0'	2.5'	3.0'	3.5'	4.0'	4.5'
<u>Larix</u>	3 yrs	4 yrs	5 yrs	5 yrs	6 yrs	6 yrs	6 yrs	7 yrs	7 yrs
<u>Pinus spp</u>							-		
<u>Pseudotsuga</u>									
<u>Abies spp</u>	4 yrs	5 yrs	6 yrs	7 yrs	8 yrs	8 yrs	9 yrs	9 yrs	10 yrs
<u>Tsuga spp</u>									
<u>Thuja</u>									
<u>Picea</u>									

All the plot site data and all the tree origin and scar dates were entered into a (Microsoft™) EXCEL spreadsheet data base. In this data base, each row represented one tree record. Site data and fire scar and tree origin dates were coded in the columns. There was one column for each even numbered potential scar or origin year (1950, 1948, 1946 . . . back to the 1500's). Odd numbered years were rounded up to the nearest even numbered year, in order to limit data base size. The result is a tabular record of all tree origin and fire scar dates. A sample from this data base is included in Appendix A.

The tree origin dates and scar dates were examined on a plot-by-plot basis to reduce this tree-based data to a separate plot-based "master fire chronology" (a sample of the master fire chronology is included in Appendix B). The master fire chronology data base took the same form as the EXCEL tree record data base, except that each line now represented one whole plot and had an entry for each fire episode on that plot. In the master fire chronology the date of each fire episode was recorded, along with the number of plot tree origin dates and fire scars indicating that fire episode. In addition, each fire episode was coded for severity, using the rules specified below. The terminology "fire episode" is used to define either a single fire, or a group of closely

occurring reburns that cannot be distinguished as separate events because of overlapping tree origin dates. This use of "fire episode" is similar to Morrison and Swanson's (1990) terminology. Below we discuss the precision in our fire episode date estimates.

Plots within approximately 400 yards of each other were used together for dating common fire episodes. However, the number of origin dates and scars per plot was recorded individually in the master fire chronology. Historical records documenting fires were used to corroborate and help date specific fire episodes.

Table 4, below, shows the amount of tree evidence per plot considered sufficient to record a fire episode in the master fire chronology. Going further back in time, these standards had to be relaxed, because it becomes progressively less likely that tree indicating a given fire episode will have survived long enough to sample. Where the Table 4 standards were not fully met, but there was evidence that we considered likely to have indicated a fire episode, it was entered in the master fire chronology preceded by a "?". Other plots within the same watershed were considered for corroborating evidence when deciding whether to record questionable fire episodes. Single origin dates for shade tolerant late seral species (western redcedar, western hemlock, mountain hemlock, grand fir, and subalpine fir) were not accepted as evidence of a fire episode, unless they were the oldest trees in the stand. In this case, the date recorded for an estimated fire is probably conservative.

Table 4 -- Number of trees/plot considered sufficient evidence of a fire episode.

	1980-1800	1799-1700	prior to 1700
NUMBER OF FIRE SCAR DATES SUFFICIENT TO INDICATE A FIRE EPISODE	2 scars within accuracy range shown in Table 5	2 scars within accuracy range shown in Table 5	1 scar within accuracy range shown in Table 5
NUMBER OF TREE ORIGIN DATES SUFFICIENT TO INDICATE A FIRE EPISODE	4 origin dates (at least 1 early seral ¹ . species) within 30 years of each other $\pm$ accuracy range shown in Table 5	2 origin dates (at least 1 early seral ¹ . species) within 30 years of each other $\pm$ accuracy range shown in Table 5	1 early seral ¹ . species origin date if there are others in watershed within 30 yrs $\pm$ accuracy range shown in Table 5
COMBINED NUMBER OF FIRE SCARS AND TREE ORIGIN DATES SUFFICIENT TO INDICATE A FIRE EPISODE	1 scar plus 2 origin dates within 30 years of each other $\pm$ accuracy range shown in Table 5	1 scar plus 1 origin dates within 30 years of each other $\pm$ accuracy range shown in Table 5	either situation defined above

¹. Seral species are western larch, western white pine, Douglas-fir, ponderosa pine, lodgepole pine, and whitebark pine. If the plot contains only late seral species, they may be used alone.

Where the fire evidence included fire scars on several trees within the accuracy ranges in Table 5, the average scar date was used to date the fire episode. Where the fire evidence only included tree origin dates, the average of the earliest 20% of the origin dates was used to date the fire episode. On south aspects, and in Douglas-fir and higher elevation subalpine fir/mountain hemlock habitat types, where only origin dates were available, the fire date was estimated to be two or four years (depending upon how severe the site was) prior to this calculated date. Obvious single outliers that didn't correlate with anything else in the watershed were generally ignored.

Because tree regeneration can continue for several decades after a disturbance, regeneration occurring over a 30 year period was considered evidence of a single fire event, unless there was scar evidence of a reburn. On more severe habitat types (Douglas-fir, subalpine fir, and mountain hemlock series) we used a 40 year period of tree origins to indicate a single fire episode.

Precision in Estimating Fire Dates

The dates for fire scars and tree origins include several possible sources of error. There is error associated with the age estimated for the stump or tree height where the ring counts were taken. Table 3 shows the standard values we used for estimating the years it took for the tree to grow to the height where we did our ring count. The 90% confidence interval on these height ages is estimated to be ± 4 years.

The majority of data came from counting tree rings on cut stump surfaces. To determine the date the stump was cut, we used harvest dates from the ranger district Timber Stand Management Record System (TSMRS -- also commonly known as the timber stand data base). However, the recorded harvest date is the date when the logging is accepted as completed by the Forest Service sale administrator. This is not always the year an individual stump was cut. The 90% confidence interval for error due to estimating harvest date is ± 1 year. There is variance due to the season that the tree was actually harvested. The 90% confidence interval for error due to estimating harvest season is ± 1 year. There is also measurement error in counting rings. This includes inaccurate counts due to difficulty in discerning tight rings, as well as inaccuracies due to both missing and false rings. Almost all counts were made in the field with a 10 or 14 power hand lens. Dates recorded in the data base were to the nearest even year, which introduced another minor source of error. The combined error resulting from inaccurate counts and recording was considered a percentage of the number of rings counted. This estimated error percentage also varied, because the older the tree is, the more likely it is to have tight rings that are more difficult to count. For origin dates in the 20th century, the 90% confidence interval error was estimated to be $\pm 2\%$ of the ring count. For the 19th century origins, the error was estimated to be $\pm 3\%$. For 18th century and earlier, the error rate was estimated to be $\pm 4\%$. Since these error rates are only estimates, one standard error rate per century was calculated. For purposes of calculation, the average fire date in the 20th century was assumed to be 1920, and in earlier centuries was assumed to be the century midpoint (e.g. 1850, 1750, etc.). Expanding on the approach used in Morrison and Swanson (1990), a root mean squared error was calculated for each century (the square root of the sum of the squares of the error estimates for each source). Using this technique, Table 5 displays the accuracy estimates of dates recorded in this study.

Table 5 -- Estimated accuracy of ages and scar dates, by century midpoints.

Sources of Error / Century & Calculation Date	est. error	1920	1850	1750	1650	1550
Counting error & missing rings to 1900= $\pm 2\%$; 1899-1800= $\pm 3\%$; 1799-1500= $\pm 4\%$ (est.) ²		2.07	18.15	93.70	187.14	312.58
Harvest date recording (est.) ²	± 1 yr	1	1	1	1	1
Harvest season estimate (est.) ²	± 1 yr	1	1	1	1	1
Subtotal -- Scar Root Mean Square Error		± 2 yrs	± 4 yrs	± 10 yrs	± 14 yrs	± 18 yrs
Estimate of age to height (error) ²	± 4 yr	16	16	16	16	16
Total -- Origin Date Root Mean Square Error		± 4 yrs	± 6 yrs	± 11 yrs	± 14 yrs	± 18 yrs

Scar dates within the above 90% confidence intervals are assumed to be evidence of a single fire episode, unless one or more trees have multiple fire scars in that time period. Tree origin dates within 30 years, plus the above 90% confidence intervals will likewise be assumed to be evidence of a single fire episode, unless there is fire scar evidence to the contrary.

Plot fire dates within these confidence intervals, and within a single watershed will be assumed to be evidence of a single fire event, unless there is some specific evidence to the contrary.

Fire Severities and Fire Regimes

We recognized three fire severities. These are lethal (stand replacing) fires, nonlethal (understory) fires, and mixed severity fires. These fire severities are recognized at the stand level. Within large fires of predominantly one severity, there are always small patches that burn hotter or cooler than the average. When the whole fire area is an irregular mixture of different fire severities, this is one piece of evidence indicating a mixed severity burn.

Lethal fires (stand replacing) are defined as those that removed 90%+ of the live tree main upper canopy layer over 90% of the stand. Many of these fires will have removed almost all the live canopy,. These are commonly crown fires, and their tree killing effects tend to be large scale and relatively uniform. Stand structures in areas dominated by lethal fires tend to be even aged, with only scattered individual residual

trees and small residual patches. In this study lethal fires are recognized by several characteristics:

1. The stand is dominated by age classes that initiated subsequent to the fire episode; residual trees predating the fire episode appear as scattered or clumpy emergents in a canopy largely made up of younger, and often smaller trees.
2. Trees that did survive the stand replacing fire are predominantly fire resistant species -- primarily larch with some ponderosa pine, and Douglas-fir.
3. Trees that survived the stand replacing event will generally display fire scars and/or heart rot marking the date of the stand replacing fire. However, in the stand as a whole, fire scars are relatively rare, because relatively few trees survive lethal fires.
4. Species regenerating after the stand replacing fire usually includes a substantial component of early seral species -- larch, ponderosa pine, white pine, Douglas-fir, lodgepole pine, and whitebark pine.

Nonlethal fire is the second severity we recognized. Nonlethal fires are defined as all fires that removed 10% or less of the live tree main upper canopy layer over 90% of the stand area. These are almost always surface or understory fires. Both intensity and frequency of these nonlethal fires may be quite variable. Their effect on understory vegetation may also be quite variable. However, they all share the characteristic of not producing major mortality in the tree main upper canopy layer. In this study nonlethal fires are recognized by the following characteristics:

1. Trees that survived the nonlethal fire are common and well distributed throughout the stand. The nonlethal fire will not have reduced overstory canopy cover significantly from what would be expected in this habitat type.
2. Trees that survived a nonlethal fire include a significant component of all species expected to be common on the habitat type -- both fire resistant species (may include larch, ponderosa pine, and/or Douglas-fir), and non-fire resistant species (may include grand fir, white pine, lodgepole pine, spruce, hemlock, and cedar). With short return intervals, the more fire resistant species tend to dominate.
3. There are usually numerous age classes represented in the stand, with the majority of the overstory canopy dominated by trees that pre-date the last nonlethal fire. Repeated short interval nonlethal fires will lead to uneven-aged stand structures with some overstory trees displaying multiple fire scars.
4. Following a single nonlethal fire -- except in the Douglas-fir and ponderosa pine habitat types -- regeneration will be dominated by shade tolerant species. On

grand fir, redcedar, and western hemlock habitat types, post-fire regeneration rarely includes shade intolerant species such as white pine (which normally requires a significant canopy opening) and larch (extremely shade intolerant and requires a hot fire that remove most duff).

5. Fire scars may be spotty or even lacking in thicker barked species (larch, ponderosa pine, and Douglas-fir) that survived an individual fire; fire scars will be more common in surviving true firs, hemlocks, cedar, lodgepole pine, spruce, and white pine; these latter species may also exhibit substantial heart rot associated with the nonlethal fire date.

Mixed severity fire is the third type recognized in this study. Mixed severity fires are fires that have mixed severities across space. Mixed fires commonly burn with variable severity across the landscape, producing irregular, patchy mosaics. These mixed severity fires include surface or understory fires hot enough to kill more than 10% of the overstory tree canopies, as well as much more severe fires that destroy the lower canopy layers, kill substantial proportions of the stand, and sometimes flare into the crowns to kill patches of overstory trees. These are not continuously running crown fires. The distinguishing feature of mixed severity fires is that 90% of the landscape experiences greater than 10%, but less than 90% mortality of the dominant overstory tree canopy. There may be small patches within a mixed severity fire that don't burn, or experience only a nonlethal surface fire. Likewise, there may be small patches where the fire crowns out and kills all the overstory trees. But these are only inclusions within a larger mosaic clearly dominated by mixed severities of between 10% and 90% overstory mortality. Mixed severity fires are recognized by the following characteristics:

1. There are two or more distinct age classes represented in the stand, with substantial proportions of the canopy represented by trees that pre-date the mixed severity fire. However, the stands are not truly all-aged.
2. Trees that survived the mixed severity fire are common and distributed throughout the stand; fire survivors are not restricted to isolated fire resistant individuals or small patches.
3. Trees that survived the mixed severity fire include large numbers of well distributed fire-resistant species (larch, ponderosa pine, and/or Douglas-fir) but also commonly include some trees of lower fire resistance. Generally, a higher proportion of fire resistant species will be represented in the age class that predates the mixed severity fire.

4. Following a mixed severity fire regeneration will be dominated by a mixture of both shade tolerant species and shade intolerant species (larch, white pine, Douglas-fir, and ponderosa pine -- on appropriate habitat types).
5. Fire scars may be spotty in thicker barked species (larch, ponderosa pine, and Douglas-fir) that survived the fire; fire scars will be common in surviving true firs, hemlocks, cedar, and white pine; these latter species may also exhibit substantial heart rot associated with the date of the mixed severity fire. There are numerous trees that display one or two fire scars, but trees with multiple fire scars are relatively rare.
6. The landscape will be a mosaic, with nearby stands displaying conditions representing different parts of the broad range described in the items above.

Fire regimes that are mixed over time -- rather across space -- are defined as variable. A common variable fire regime pattern is to have short return interval nonlethal or mixed severity fires, with occasional long return interval lethal crown fires. Because variable fire regimes are distinguished by variation in severity between different fires, they cannot be used to characterize a single fire episode. To characterize individual fire episodes this study will use the three fire severities defined above. Fire regimes that regularly include fires of different severities -- that vary through time -- will be differentiated as variable fire regimes.

Calculating Mean Fire Return Intervals

Once the Master Fire Chronology was built, we created a third EXCEL data base (called "fire intervals" -- see example in Appendix C). In the fire intervals data base, there was one row for each plot. Each fire episode date for each plot was entered with a code indicating whether or not it was a lethal fire. For each plot the intervals between all fire episodes were calculated and then averaged creating a mean fire return interval for each plot, for both lethal fires and all fires.

The time period between the last fire episode and the sample date was included as one of the intervals. Since there hasn't been a major stand replacing fire in the Coeur d'Alene River basin since 1931, it might be argued that human fire suppression has made this last period artificially long. On the other hand, there have been several major stand replacing fires in the Bonners Ferry study area during this same period. And,

undoubtedly, terminating the interval at the sampling date artificially shortened the fire return period for some stands. Plots averaged 3.27 fire episodes per plot, so one estimate for this last interval did not overwhelm the averages. Overall, we felt that these introduced errors were probably close to self compensating when averaged over the whole study area.

We did try simply eliminating any open ended intervals. There were quite a few plots that only had one or two fires and long intervals between fires. The effect of eliminating open ended intervals was to eliminate a major portion of the longer fire-free intervals and artificially shorten the averages. We felt this introduced more bias than including open ended intervals, and dropped this approach.

Significant activity by Euro-American man in the Coeur d'Alene River Basin began about 1880. To test whether this human activity had any affect on fire regimes, we calculated pre-1880 mean fire return intervals, using only those intervals that began with a fire before 1880. To avoid biasing these pre-1880 intervals we used the same methodology for pre-1880 mean intervals between all fires as we had used for the full time period calculations. If a fire beginning prior to 1880 was followed by a second fire after 1880, that interval was the last used in these averages. The full study period recorded no fires after 1942 -- a period of 50 years. To maintain uniformity in methods, if a fire occurring after 1830 (50 years before 1880) had not had another fire up to 1992, that last open ended interval was not included in the averages. If a fire occurring before 1830 was open ended, we let 1880 terminate the interval (just as 1992 terminated open intervals for the full study), and included this in the averages. That way, we did not artificially shorten the averages by dropping plots with only one fire a long time ago.

When considering only lethal (stand replacing) fire, the majority of stands only had one lethal fire, and thus were open intervals. If we automatically used 1880 to close this open interval rather than 1992, we would artificially shorten the average between lethal fires, simply as an artifact of our methodology. Therefore, for lethal fires we only used complete intervals that had begun prior to 1880. On an individual watershed basis, we ended up with very few samples of pre-1880 lethal fire intervals.. However, for the study area as a whole, we had a reasonable sample size.

Review of the raw data showed an apparent abrupt decrease in fire frequencies prior to 1760, so a similar procedure was used to examine only those fire intervals that began

prior to 1760. Here the fact that we were dropping back half the study period, and small sample size prevented us from evaluating lethal fire return intervals.

Plots were sorted by watershed, and mean fire return intervals were developed for watersheds. Overall mean fire return intervals were also developed for the entire study.

We were also interested in identifying specific, area-wide major fire episodes. We went back to the Master Fire Chronology, and located specific fire episodes that appeared in 5% or greater of the plots in each study. When a major multi-plot fire episode was identified, it was assigned a single date, based on the preponderance of evidence -- with scar dates more heavily weighted. Historical records and Forest Service fire maps were also used to help assign proper dates of the more recent fire episodes.

RESULTS

The results look very different depending upon the spatial scale, the area, or the time period examined. It's of particular importance whether we're looking at things from a river basin perspective (these study areas were small river basin size: ~230,000 to 570,000 acres), a watershed scale (~5,000 to 25,000 acres), or a stand scale (plot data was taken over an area of ~2 to 7 acres, representing small stands).

Fire Return Intervals

The Coeur d'Alene fire study identified 21 major fire episodes (fires affecting 5% or greater of the sample plots in the Coeur d'Alene Basin), and numerous minor fires. The first major fire apparent in the Coeur d'Alene data set occurred in 1542 and the last was in 1931. This works out to an average of one major fire every 19 years, somewhere in the 570,000 acre Coeur d'Alene fire study area. Each one of these major events only affected a minority of this whole area. Table 6 displays the results from major fire episodes, viewed from a river basin perspective.

For the historical fire episodes from 1889 though the present, these plots are not a representative sample. During the period 1889 to 1931, many watersheds not only burned particularly severely, but reburned several times. Most of the watersheds that

burned in this period are largely unroaded because the trees have only recently become large enough to be valuable for logging. Because of the lack of residual trees to sample, and because access was so difficult, watersheds that burned in the big fires of the late 19th and early 20th centuries are under-represented in the Coeur d'Alene study. In particular, the 1889, 1910, 1919, and 1926 fires probably burned a larger proportion of the Coeur d'Alene River Basin than indicated by the percent of sample plots they showed up on.

The Coeur d'Alene study also recorded minor fires through 1942. Tree origin dates and occasional fire scars occur through the 1970's. We know there have been other minor fires in the Coeur d'Alene Basin right up through the 1980's. However, these all burned very small areas, and were usually associated with logging activity or slash disposal. Because of the difficulty of distinguishing escaped fires from slash disposal activities, and because we know that since 1942 actual wildfires represented only a tiny fraction of tree fire scars, we did not record any fire episodes after 1942.

TABLE 6 --- Major fire episodes and intervals between major fire episodes in the Coeur d'Alene Fire Study. A major fire episode is defined as one that shows up in 5%+ of the plots in this study.

MAJOR FIRE EPISODES IN THE COEUR D'ALENE RIVER BASIN						
SAMPLE YEARS	*ESTIMATED	INTERVAL BETWEEN	AVERAGE	# PLOTS	% SAMPLE PLOTS	
INCLUDED	DATE	EPISODES (IN YRS)	INTERVAL (YRS)	WITH EPISODE	WITH EPISODE	NOTES
1534-1560	<u>1542</u>			10	6.8%	
		38				
1570-1602	<u>1580</u>			18	12.3%	
		74				
1652-1676	<u>1654</u>		56	13	8.9%	
		84				
1728-1748	1738			14	9.6%	
		26				
1760-1768	<u>1764</u>			15	10.3%	
		8				
1770-1782	<u>1772</u>			35	24.0%	
		18				
1788-1798	<u>1790</u>			15	10.3%	
		14				
1802-1806	1804			12	8.2%	
		10				
1810-1826	<u>1814</u>			49	33.6%	May be closely spaced double burn ??
		16				
1828-1838	<u>1830</u>			27	18.5%	
		14				
1840-1848	1844		13	26	17.8%	
		15				
1852-1866	<u>1859</u>			55	37.7%	May have been double/triple burn in many sites (some clustering @ 1854,59, & 64)??
		11				
1868-1872	1870			17	11.6%	
		8				
1876-1882	<u>1878</u>			27	18.5%	
		11				
1888-1892	<u>1889</u>			15	10.3%	Sampling underrepresented; magnitude determined largely from historical record
		7				
1894-1900	1896			24	16.4%	
		8				
1902-1906	1904			15	10.3%	
		6				
1908-1912	<u>1910</u>		8	25	17.1%	Sampling underrepresented; includes 1908 fire ??; magnitude from historical record
		9				
1918-1920	<u>1919</u>			8	5.5%	Sampling underrepresented; includes 1918 fire ??; magnitude from historical record
		7				
1923-1928	<u>1926</u>			9	6.2%	Sampling underrepresented; fires 1923,24,25,26,28 -- hard to distinguish in data:
		5				-- 1926 larger than others combined; magnitude from historical record
1930-1932	<u>1931</u>			10	6.8%	Date from historical record
	1542-1932	AVERAGE INTERVAL	19			

*Underlined dates = 3%+ of total study area shows a lethal event

From a river basin perspective the long term mean fire return interval was one major fire every 19 years. We were also able to identify specific time periods with different averages, and there were discrete boundaries where these averages changed.

Between 1878 and 1931, somewhere in the river basin there was an average of one major fire every eight years. Between 1764 and 1878, the river basin average time between major fires was 13 years. Between 1542 and 1764 we identified an average of one major fire every 56 years. In our most recent period, the river basin has not had a major fire since 1931 -- a period of 61 years.

From the stand perspective (vegetation blocks with relatively uniform canopy of from ten to a few hundred acres -- the scale that we apply treatments to; our two to seven acre plots are considered a stand sample) average fire return intervals look very different.

Table 7 displays average fire return intervals from a stand perspective. These are the fire return intervals that are relevant in trying to understand the range of historical variability in stand structures.

Table 7 -- Average fire return intervals for stands in the Coeur d'Alene Fire History Study; separated by time periods and geographic area.

	Fire Regime	Whole Coeur d'Alene Basin Study Area	Interior -- North Fork Coeur d'Alene River	Rathdrum Prairie Face -- Hayden Lake Watershed
Full Study: 1992-1540	Lethal Fires	191 yrs	203 yrs	138 yrs
	All Fires	80 yrs	84 yrs	62 yrs
Prior to Euro-American Settlement: Prior to 1880	Lethal Fires	200 yrs	212 yrs	149 yrs
	All Fires	64 yrs	65 yrs	55 yrs
Early Period: Prior to 1760				
	All Fires	115	106	

The stand level results are displayed for both the whole study area and two different geographic subdivisions. These two geographic subdivisions -- the Rathdrum Prairie face and the Coeur d'Alene interior -- have significant differences in fire regimes. It is more meaningful to deal with these geographic areas as representing separate conditions than to use a combined average for the whole study. T tests show highly significant differences (at the 99% confidence level) in the area differences between mean fire return intervals.

The Hayden Lake watershed is adjacent to the Rathdrum Prairie. The Rathdrum Prairie is dominated by drier habitat types (primarily grand fir and Douglas-fir). Prior to Euro-American settlement, the Rathdrum Prairie had extensive areas of large open-grown ponderosa pine, which often indicates short fire return intervals. Although the Hayden Lake watershed itself has moister habitat types (hemlock and cedar habitat types dominate) and landforms similar to the rest of the Coeur d'Alene study area, we hypothesized that being adjacent to, and immediately down wind from an area with different habitat types, cover types, and fire regimes might have an impact on Hayden area fire return intervals. The data seems to support that hypothesis. For the full time period in this study, the average fire return intervals in the Hayden Lake watershed were 138 years for lethal fires and 62 years for all fires. These fire return intervals in the Rathdrum Prairie face are significantly shorter than those for the interior of the Coeur d'Alene River Basin.

The interior of the Coeur d'Alene River Basin is an enclosed drainage with a relatively uniform mosaic of moist habitat types and rolling landforms. Hemlock habitat types dominate the landscape, with grand fir habitat types only on drier aspects and Douglas-fir habitat types only on breaklands and landforms with unusually shallow or droughty soil. Here, the fire return intervals are longer than for peripheral areas facing the drier Rathdrum Prairie. In the interior of the Coeur d'Alene, for the full period 1540 to 1992, the average fire return interval was 203 years for lethal fires, and 84 years for fires of all severities.

Both the periphery and interior of the Coeur d'Alene, can be characterized as having variable fire regimes. There is a pattern of relatively long return interval lethal (stand replacing) fires, with mixed severity and nonlethal fires on shorter intervals. The average stand might experience one to three lower severity fires in the interval between stand replacing fires.

There is great variability in fire return intervals. The intervals between nonlethal and mixed fires is especially variable, creating a coefficient of variation of 53.4% for all fires in the Coeur d'Alene interior. Table 8 provides a picture of some of this variation in fire return intervals at both the stand and watershed scales. It should be noted that while individual stands have a very wide range of variation -- especially in time between

individual fire episodes -- when we look at watershed mean fire return intervals, the range of variation is much narrower.

Table 8 -- Variation in fire return intervals.

1. Variation in Individual <u>Stand</u> Fire Return Intervals --	
-- <u>Interior mean stand return interval for lethal fires:</u>	
-- Average = ...	203 yrs
-- Standard deviation = ...	± 82 yrs
-- 68% confidence interval = ...	121 - 285 yrs
-- Range of stand mean return intervals = ...	61 - 452 yrs
-- Range of individual fire intervals = ...	18 - 452 yrs
-- <u>Interior mean stand return interval for all fires:</u>	
-- Average = ...	84 yrs
-- Standard deviation = ...	± 45 yrs
-- 68% confidence interval = ...	40 - 129 yrs
-- Range of stand mean return intervals = ...	24 - 228 yrs
-- Range of individual fire intervals = ...	4 - 322 yrs
Range of Variation in Interior <u>Watershed</u> Mean Fire Return Intervals -- (All watersheds include a mix of habitat types, landtypes, and slope positions)	
-- Between fires of any severity = ...	68 - 107 yrs
-- Between lethal fires = ...	153 - 259 yrs

1. Ranges do not include closely spaced double burns that could not be clearly distinguished from field data

Fire Size

This study records small fires that show up in only one, or a small number of plots in a watershed. However, large fires (thousands to tens of thousands of acres in size) stand out prominently in the data. All of the 21 fire episodes listed in Table 7 show up in a minimum of 5.5% or more of our plots. If the size of these fire episodes was proportional to the percent of plots in our 93,000 acre sample area, the minimum burned area of these 21 events would have been 5,100 acres within our sample area. The average area burned in these 21 fire episodes would have been 13,300 acres. The two largest fires recorded in our data -- the 1859 and 1814 fire episodes -- show up on 37.7% and 33.6% of our plots. (This includes both lethal burns and burns of lower severity recorded in the same fire episode). If the burned area in our 93,000 acre sample area was proportional to the plot percent, this means we are recording fire episodes that cumulatively burned over 35,000 acres and 31,000 acres respectively. These potential fire sizes are only within our 93,000 acres of sample watersheds, which only represents 16% of the North Fork Coeur d'Alene River basin. During these apparently severe fire years, many more acres probably burned in the Coeur d'Alene

basin as a whole. These would not have all burned in one big fire, but likely represent several major and numerous minor fires during severe fire years.

In some cases it appears that major parts of adjacent watersheds burned in single large fires. The 1814 fire episode shows up on 88% of the plots in our Cougar Gulch/Upper Bumblebee watershed sample areas -- largely as a lethal severity (stand replacing) burn. If the acres burned were proportional to the percent of plots represented, this translates to 11,512 acres that probably all burned in one big fire (not all lethal burn severity). In fact, the only plots in Cougar Gulch that don't show evidence of the 1814 fire episode experienced a lethal burn in 1844, and it may be that evidence of the 1814 fire was obliterated in this later burn.

The 1814 fire episode also shows up in 73% of the plots in upper Tepee Creek, which adjoins the head of Cougar Gulch. This adds another 3,000 acres to the 11,512 acre burned area in Cougar Gulch, for a likely contiguous burned patch of 14,512 acres.

The 1814 fire episode also shows up in 87.5% of the plots in the Downey Creek watershed, approximately seven miles northeast (and downwind) from Cougar Gulch. This adds another potential 5,587 acres to this fire episode. Unfortunately, we don't have any plots in the intervening area, so we don't know if the burn here was contiguous with the previous two areas.

DISCUSSION

This study reports that the North Fork Coeur d'Alene River Basin had a variable fire regime characterized by both infrequent large lethal (stand replacing) fires, and more frequent shorter return interval nonlethal and mixed severity fires (see Tables 7 and 8). There was also great natural variation in fire frequencies and patterns. Some of this variation is scale dependent, some is linked to spatial differences in the environment, some is due to changing conditions over time, and some may be simply due to chance. All these differences must be examined to understand the fire regime and its effects on the landscape vegetation structure.

Fire return intervals look different depending upon whether we're examining intervals between fires somewhere in a 570,000 acre river basin, in a 15,000 acre watershed, or

between fires reoccurring in small stands (see Tables 5, 6, and 7). Fire return intervals are scale dependent. Results from any given scale are only applicable when applied at the same scale. Several different scales have to be examined to really understand the fire regime.

Variability in Fire Severity

To understand the historical range of variability in these moist northern Idaho forests we have to understand the functions performed by both the infrequent, large lethal stand replacing fires, and the more frequent nonlethal and mixed severity understory fires. In addition to cycling carbon and nutrients, the infrequent large lethal (stand replacing) fires played a dominant role in resetting the successional sequence and structuring the vegetation matrix across the landscape. However, the nonlethal and mixed severity fires were also important. Most stands apparently experienced an average of one to three of these low severity burns between lethal fires (see Table 6). These lower severity fires would reduce ground fuels, reduce ladder fuels, thin stands, and favor larger individuals of fire resistant species. The landscape as a whole would have larger trees and a greater proportion of fire resistant species (larch, Douglas-fir, and ponderosa pine), than if these mixed severity and nonlethal fires had not occurred.

Lower severity fires structured how the landscape responded when a lethal severity fire did occur. The lower severity fires increased the proportion of the landscape with big trees and open canopies that would not sustain a crown fire. Reduction of ladder fuels would mean that even high intensity fire might not reach tree canopies in some cases. The larger trees that grew as a result of the thinning would be more likely to survive even intense fires. The net result would be that even mostly lethal severity fires would be likely to leave more individual residual trees and patches of residual trees than if the lower severity fires had not occurred. The effects of lethal fire events would be less uniform as a result of the lower severity fires. This would both speed up succession to conifer dominance in some places, and increase landscape level diversity.

On the other hand, repeat burns would tend to significantly extend the length of forb and shrub dominated successional stages. Many researchers in northern Idaho (Arno 1980; Larsen 1925; Leiberg 1897; Pyne 1982) documented large fires followed by double and triple reburns occurring a few years to four decades later. A single fire that creates

major mortality may increase the probability of a closely spaced reburn because of the fuel conditions created.

This study has documented cases of reburns (for example the Yellow Dog/Downey watershed almost all burned in either the 1814 or 1830 fire episodes; the majority of it reburned in approximately 1854). The dating methodology in this study is not precise enough to distinguish reburns that were ten years or less apart. For that reason, this study likely under estimates the frequency of reburns. We make no estimate of reburn frequency, other than to say it was a common occurrence, and probably led to a landscape with a higher proportion of forb and shrub dominated early successional stages than would be expected from simply looking at average lethal fire return intervals.

Spatial Variability

Spatial location accounts for some of the variation in fire patterns. Even within an ecosystem, there are well documented links between fire regimes and physical site characteristics such as habitat types and topographic features (Arno 1980; Barrett 1993; Barrett and Arno 1991; Barrett, Arno, and Key 1993??; Habeck and Mutch 1973; Morrison and Swanson 1990). This study also observed significant spatial variation as result of juxtaposition. This occurs in two ways. First, fire regimes depend -- in part -- on what sort of landscape matrix a given piece of ground occurs in. Many studies in the Northern Rocky Mountains have documented Douglas-fir habitat types as having relatively short return interval nonlethal and mixed severity fires (Arno 1976; Fischer and Bradley 1987; Barrett and Arno 1991; Losensky 1993). The eight plots in this study that were in the Douglas-fir habitat series were mostly river breaklands, or steep south slopes with unusually shallow soil, sitting in a larger matrix of moist hemlock and grand fir habitat types. These Douglas-fir sites may have somewhat shorter return intervals than the landscape as a whole (148 years versus 203 years for lethal fires and 71.6 versus 84 years for all fires), but they still follow the general landscape pattern of having a variable fire regime that includes relatively long interval stand replacing fires. The individual site characteristics do matter, but the pattern of the overall landscape matrix dominates the fire regimes.

Patterns on adjacent landscapes are also important. The Hayden Lake/Rathdrum Prairie face may have a somewhat higher percent of drier habitat types than the interior of the Coeur d'Alene basin, but it is still dominated by hemlock series habitats. Yet it has significantly shorter fire return intervals than the interior Coeur d'Alene Basin (lethal fire return intervals only 68% as long and all fire intervals only 74% as long -- see Table 7). This difference generally holds even when only Hayden Lake plots with hemlock habitat types are considered. We believe the driving factor here is that the Hayden Lake watershed is immediately adjacent to, and downwind from the large Rathdrum Prairie area which is dominated by drier habitat types, pine cover types, and much shorter fire return intervals. To understand the fire regime of an area, it is necessary to understand the influences from adjacent areas.

Temporal Variability

Some people have questioned whether large stand replacing fires were common in northern Idaho prior to Euro-American settlement, or whether the numerous fires of the late nineteenth and early twentieth centuries (well documented in the historical record) were an anomaly resulting from the activities of Euro-American settlers. This study should put that question to rest. The number of lightning fires regularly experienced in northern Idaho is more than adequate to account for a disturbance regime that includes regular major wildfires (see Table 1). The Coeur d'Alene study documents a continuous record of large fires with significant areas of lethal severities, as far back as 1542. The only reason the record terminates at that point is because we are approaching the potential life span of the tree species most useful for recording fires (western larch), and because the number of fires in our study area during this 450 year period is so great that there's low probability of any trees surviving to record earlier fire events. Wildfire, and especially large lethal fires, have been a major disturbance mechanism in the Coeur d'Alene River basin for at least the past 450 years.

When viewed from the stand scale, there are minor differences between the fire regimes for the entire study period and those for the pre-1880 period (see Table 7). The pre-1880 data shows about a 4% lengthening of the mean interval between stand replacing fires and a 23% decrease in the average interval between all fires, as compared to the averages for the entire study period.

When examining the river basin scale, there also appears to be some change in mean major fire intervals at approximately 1880 (see Table 6). On a river basin basis, prior to the 1878 fire episode the river basin mean fire return interval for major fires is 13 years and between 1878 and 1931 the mean fire return interval is eight years.

Part of this difference is undoubtedly an artifact of our methodology. As we go farther back in time, we are less likely to find evidence of any particular fire, and there is less precision in our fire dates. Because our fire dates are less precise, we are more likely to wash together closely spaced fire episodes that occurred further back in time. For example, the major 1859 episode that we identified could possibly be as many as three different fires. There is some clustering of dates around 1864, 1859, and 1854.

However, because there was so much overlap in plot dates we decided to call it all one episode. If we had recognized three separate episodes, this would tend to shorten average river basin lethal return intervals for the pre-1880 time period.

Even given these methodological considerations, there is evidence of particularly large and severe fires in the late 19th and early 20th centuries (Larsen 1922; Pyne 1982). The activities of miners, settlers, and railroads undoubtedly increased the number of fire starts. But before any change in fire regimes is ascribed solely to Euro-American settlement activities, climate change must also be considered. The late 19th century marks the end of the Little Ice Age climate period (Pielou 1991), and a shift to a warmer climate. In particular, the period of 1916 to 1940 has been documented as the most severe drought in the Northern Rocky Mountains in the previous 280 years (Leaphart and Stage 1971). Lightning and unusual drought were clearly directly responsible for some of the largest lethal fires during this period including some of the big blowups of 1910 (Larsen 1922; Pyne 1982). River basin-wide mean fire return intervals may have been somewhat shorter between 1880 and 1931 than during the previous period, and some particularly large and severe fires may have occurred, but climate changes overlapping with Euro-American settlement make it difficult to identify a single cause. Human activity and climate change were probably both contributing factors. In any case, when we examine fires for the late 19th and early 20th centuries compared to the record since 1540, they appear to be within the broad range of historical variation.

Part of the reason that the stand scale pre-1880 fire return intervals don't differ in major ways from intervals for the entire study period is that the impacts of Euro-Americans may be somewhat self compensating. In the late 19th and early 20th centuries the

activities of miners, settlers, and railroads may have contributed to an increase in fire frequency and severity. Since the mid 1930's there has been almost complete suppression of lower severity fires (which also means that some low severity fires that might have become stand replacing as the summer dried and warmed were put out before they had a chance to grow). These two effects somewhat cancel each other out in the stand averages.

The 60+ years (since 1931) period of almost complete exclusion of lower severity fires may be creating more extensive dense and uniform stands than would be typical of the last 450 years. This, in turn, may set the stage for larger and more severe lethal fires in the future. However, we did not assess the interaction between this sort of fire suppression and recent extensive timber harvest patterns in the Coeur d'Alene Basin.

The loss of fire evidence through time tends to gradually widen out our calculated mean intervals between major fire events. This could explain some of the difference between pre and post 1764 fire intervals. For example, there may have been more major fires prior to 1764, but the evidence of those burns just didn't survive all the disturbance since that date. Knowledge of those events would have shortened pre 1764 average fire return intervals.

The loss of precision in fire dates as we go back in time, and the loss of fire evidence with the passage of time mean that we shouldn't put too much emphasis on differences in exact values for river basin mean fire return intervals at different time periods. However, the magnitude of some of the changes in river basin mean fire return interval for different time periods is quite large and the boundaries of these changes are quite abrupt (see Table 6 for the intervals before and after 1764). This large and abrupt change in mean fire return intervals indicates that despite the limitations of our data, some real change was likely occurring in the ecosystem.

Climatic Patterns Through Time

Regional climate change operating on the scale of decades and centuries may be implicated in the major fire patterns we've observed. The historical record tells us that some relatively recent fires were quite large. In particular, the 1919, 1910, and 1889 burns were very large and severe both in the Coeur d'Alene and throughout the

Northern Rocky Mountains (Larsen 1925; Pyne 1982). We've already discussed their possible link to the end of the Little Ice Age and a major drought. However, as we go back in time, other particularly large fire episodes stand out in the Coeur d'Alene data. In particular the 1859, 1814, 1772 and 1580 fire episodes show up on a large proportion of these plots. These older events are notable, because of the low probability that evidence would survive that long. For example, the 1580 fire episode shows up on 12% of our plots. For a 412 year old fire to still be evident on so many plots after such a long period of time, it must have been particularly large and severe. This suggest some climatic link.

Prior to 1764, there is an abrupt decrease in fire evidence on these plots and a lengthening of river basin scale mean interval between major fire episodes (Table 6). Even the stand level fire intervals, with a limited sample size, show an increase in fire-free intervals prior to 1764 (Table 7). However, in the 1500's there is an abrupt spike in the number of plots showing fire activity; this is the 1580 and 1542 fire episodes we identified. Mehringer has reported that the late 1500's were a period of unusual drought in the nearby Columbia Basin (Mehringer 1994).

It's interesting to note that in the British Columbia interior wet belt forests about 250 miles north of the Coeur d'Alene Basin, there was also a significant change in fire return intervals in approximately 1760. In the Canadian Glacier park, Johnson, Fryer and Heathcott (1990) find that fire intervals prior to 1760 were significantly shorter than after 1760. They ascribe this change to climate shifts related to the Little Ice Age. The time of this shift in landscape scale fire frequencies is the same as we found for the Coeur d'Alene Basin, but the shift is in the opposite direction. This raises the possibility that climatically induced changes in fire regimes may occur on a subcontinental scale, but the specific way the change manifests may differ from region to region.

The major fire episodes prior to 1859 that we recognized in the Coeur d'Alene study were identified without reference to any historical records or other studies (see Table 6). Subsequent review shows that several other fire studies in the Northern Rocky Mountains have identified similar events and patterns to what we've found in the Coeur d'Alene. Table 9 displays some of the regional correspondences we've found in the literature. There is strong overall correspondence between major fire dates and patterns from various Northern Rocky Mountain fire history studies. The correspondence between the Sheep Mountain Bog Study in the Missoula area

(Hemphill 1983) and the 1542 to 1772 dates and patterns from the Coeur d'Alene Study is particularly noteworthy. Particular dates such as 1542, 1738, 1764, 1772, 1814, 1830, and 1859 appear to be regional episodes. This strongly suggests that regional climate patterns are responsible for many of the major fire episodes we've identified on the Coeur d'Alene.

Table 9 -- Correspondence between fire events in various fire history studies in the Northern Rocky Mountains.

1. Coeur d'Alene Study, ID -- Zack 1994 (major fires only)	Dromedary Study -- Lolo N. F., MT -- Barrett 1991	Sheep Mtn Bog Charcoal, Lolo N.F., MT -- Hemphill 1983	Cook Mtn, Clearwater N.F. ID -- Barrett 1982 (major fires only)	White Sands -- Clearwater N.F., ID -- Barrett 1993	Fern Star, Clearwater N.F., ID -- Barrett 1993	Lake McDonald, Glacier N.P., MT -- Barrett, Arno, & Key 1994??
<u>1542</u>		1541	1535			
					1563	
<u>1580</u>		1577				
1654						
	1667					
	1683		1680			
					1693	
					1715	
<u>1738</u>		1736	1736	1734		1735
	1755	1757		1752		
<u>1764</u>	1761				1763	
<u>1772</u>		1772	1772	1772		
			1784			
<u>1790</u>	1794					
						1798
<u>1804</u>					1805	
<u>1814</u>					1816	1813
<u>1830</u>		1833		1829		
		1834				
<u>1844</u>			1842			
	1849	1850				
<u>1859</u>	1856		1862			1856
	1868	1868				
<u>1870</u>			1872			
1878						
					1884	
<u>1889</u>	1889	1889	1889			

1. Coeur d'Alene fire dates in bold and underlined correspond with dates found in other fire studies in Northern Rocky Mountains. The whole line is in bold when at least 2 other studies correspond with a Coeur d'Alene date.

Fire Regimes and Landscape Vegetation Patterns

This study identifies stand mean fire return intervals for two different subdivisions of the Coeur d'Alene basin (Table 7). However, fire return intervals are highly variable (Table 8).

The variability in fire return intervals and patterns is every bit as important as the mean values in terms of understanding the historic range of variability in vegetation pattern. For example, the mean fire return interval for lethal fires in the interior Coeur d'Alene River is 203 years. However, given the reburn pattern that we discussed above, and given the 82 year standard deviation in the distribution of return intervals, it's apparent that a 200 year rotation would come nowhere near duplicating the landscape pattern of age class and successional stages likely to result from this fire regime. If this was a normal distribution, we would expect to find that 16% of stands went more than 285 years between stand replacing fires and another 16% of the stands had two lethal fires in less than 121 years.

Analyzing the exact distribution in fire return intervals and the resultant landscape pattern is beyond the scope of this study. However, even without this analysis, the variation in fire return intervals holds several important lessons for management. If we're trying to understand the range of historic variability, we must look at not only the mean fire return intervals, but the range of variation in return intervals. The range of variation highlights that both young early seral forb, shrub, and shrub/sapling stages, and old growth structural stages probably existed in greater proportions than would be expected from a simple 200 year fire rotation.

Likewise, the dense stem exclusion structural stages (Oliver 1990) pole and small sawtimber stands were probably less common than a simple 200 year fire rotation might suggest. Common mixed severity understory fires frequently shorten the duration of dense stem exclusion stages by thinning and breaking holes in uniform canopies. These mixed severity fires tend to produce more heterogeneous stand structures and more within-stand structural diversity than would be expected from simple 200 year lethal fire rotations.

In addition, variation in fire severity on the landscape scale allows some residual large trees, patches of trees, and snags to persist even through lethal fire episodes. Some of

the spatial variability in fire severity is due to chance and some is due to topographic position. We need to consider how the functioning of specific topographic sites contributes to the overall landscape pattern. During the field work for this study, we found that certain topographic positions were more likely to have old residual trees (especially larch) that survived numerous fire episodes. These topographic positions were of two sorts. First, there were the more exposed topographies, such as ridgetops, shoulders, prominent spur ridges, and breaklands. We ascribed the higher probability of finding large residual trees in these exposed landscape positions to more rapid seasonal drying, which would increase the probability of understory fires -- promoting open stand structures with lower fuels concentrations and large, fire resistant trees. Then, during the big lethal fire swept across the landscape, the large trees on these more exposed topographies have a higher probability of surviving. They become a source of biological legacies that promote biodiversity, a conifer seed source for regenerating the forest, and a source of the large snags and woody debris that serve important biological functions for wildlife habitat. In some cases, there are enough of these large residual trees to sustain some old growth attributes through stands dominated by younger post-fire age classes.

These exposed topographies were probably over-sampled in this study, because this is where we were most likely to find the oldest trees useful for dating long fire sequences. There is some chance that, as a result of this sampling bias, our study over-states the frequency of nonlethal and mixed severity fire. But, evidence of lower severity fire so was ubiquitous on all our plots, that we still feel confident that lower severity fire occurred more frequently than lethal fire. Even where residual trees were left on our plots, we still feel we were able to generally determine when a fire event was lethal. Therefore, we do not feel there's any significant bias in the lethal fire frequencies in this study.

The other topographic positions more likely to have old residual trees that survived numerous fire events were the more protected and moist landtypes. These include wider riparian zones, moist flats, north slope coves and benches, and the lower part of steep north slopes. Here, above average moisture and slow drying make lethal fires less likely. When most upland sites experience a lethal fire, these moist topographic positions will often only experience a patchy lower severity underburn. Old larch, white pine, Douglas-fir, cedar, and hemlock are commonly found in these landscape positions. Unfortunately, these moist landscape positions are severely under-represented in this

study. The oldest stands are dominated by cedar and hemlock; old trees of these species have so much rot that it is impossible to get accurate ages. We know these trees are very old, because several hundred rings can often be counted before hitting a large hollow center. In the Coeur d'Alene, the vast majority of the larger riparian zones and flats with the big old trees were harvested so long ago that even if stumps are still present, it is no longer possible to do accurate fire dating. These moist sites did sometimes have lethal fires -- that stump and snag evidence does exist (for example -- North Fork St. Joe River). However, without any fire return interval data, all we can say is that average lethal fire return intervals in these moist topographic positions were probably significantly longer than the overall 203 year average for the interior basin -- possibly several times as long on the wettest riparian sites.

Because the unusually moist sites and riparian zones were under sampled, and because we suspect fire return intervals were longer there, the averages in this study do not reflect the entire landscape. The stand level fire return intervals in this study represent a mean value for upland sites, exclusive of riparian zones.

Together, these two landscape positions -- the more exposed upper slope ridges and shoulders; and the more protected riparian zones and north slope coves, toe slopes, and benches -- are the areas with the highest likelihood of avoiding lethal fires long enough to develop significant old growth characteristics. However, the composition and structure of the old growth in these two topographic positions would be quite different.

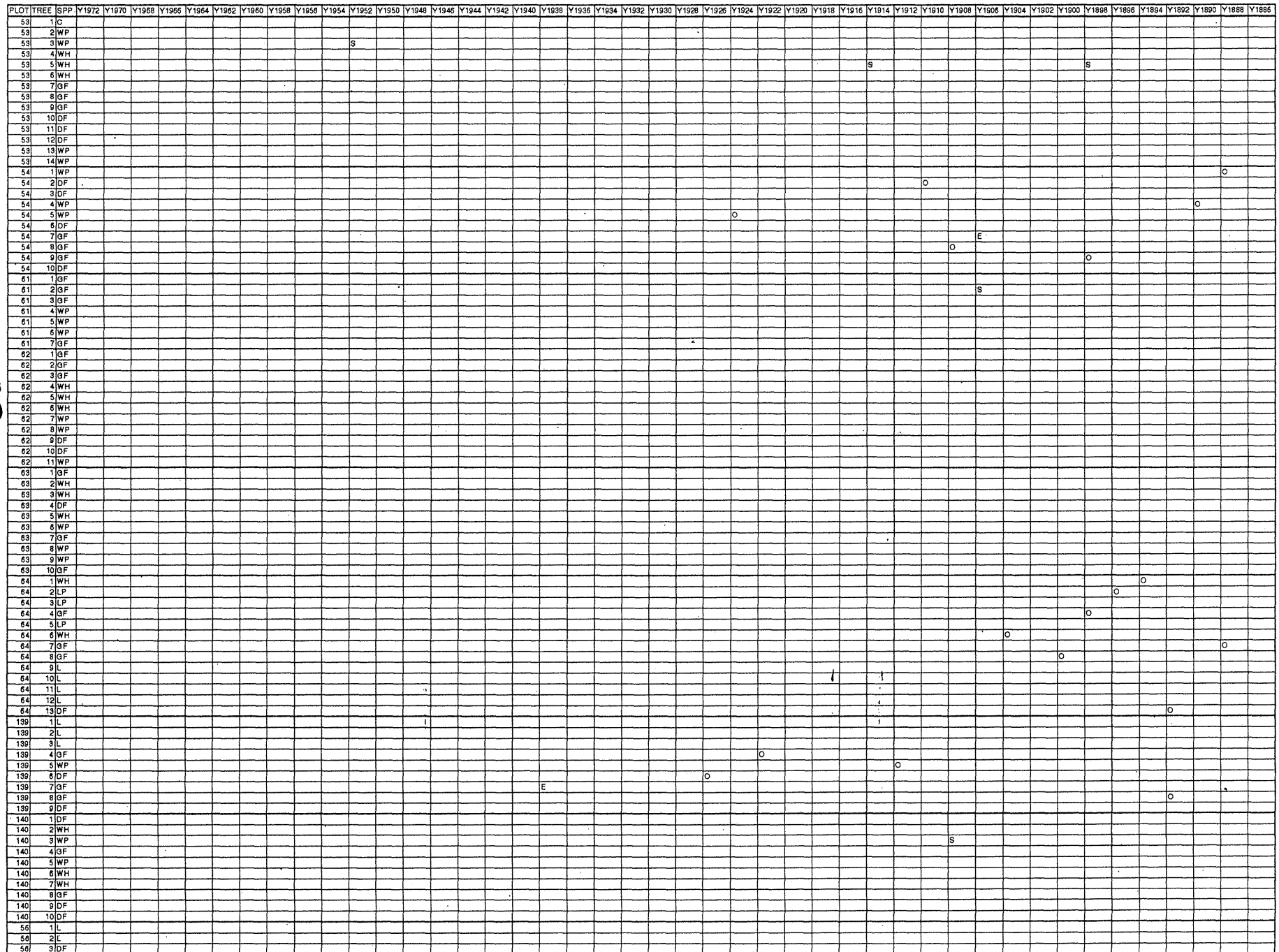
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APPENDIX A

Tree Origin and Fire Scar Data Base





APPENDIX B

Master Fire Chronology

CD'A MASTER CHRONOLOGY

B-1

ART ZACK

CD'A MASTER CHRONOLOGY

PLOT	Y1848	Y1846	Y1844	Y1842	Y1840	Y1838	Y1836	Y1834	Y1832	Y1830	Y1828	Y1826	Y1824	Y1822	Y1820	Y1818	Y1816	Y1814	Y1812	Y1810	Y1808	Y1806	Y1804	Y1802	Y1800	Y1798	Y1796	Y1794	Y1792	Y1790	Y1788
108		MS3																	LS103												?S1
109			?O2															?LO2													
110																			LO11												
111																															
112																	LS206														
113																		LO12													
114		NS2							NS4								?S1														
115																	LO9														
42							?LO1																								
43							LO4																								
44								LO5																							
45																															
46								LO4																							
47										LO4																					
48																															
49																		LO8													
50																															
51	LO7																														
52																															
53								LO13																							
54																															
61																			LO7												
62														LO10							LO10										
63																															
64																LO4															
139															?MO1																
140												LO10																			
56												LO6																			
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58															LO7																
59																				LO7											
60																															
124	MS202																MS206														
125																															
126									?O1																						
130						LO10																									
131						LO6																									
132						LO7																									
133										LO4																					
141												LO10																			
142																															
143										?MS102																					
127																															
128																															
129																?S1															
69															?MO1																LO8
77																														LS102	
78					MS403																										LO9
79									MO3																	MO3					
80	?S1E2																					MS501									
70																								MO11							
74																															
75																								MO4							
76																															
83																							MO6								
84																		?NO2													
85																															
65																									?MO3						
66									?NS1															LO4							
67																								?S101							
68																														?MO2	
71										?NO2																					?MS101
72																														?MO2	

B-2

PLOT	Y1786	Y1784	Y1782	Y1780	Y1778	Y1776	Y1774	Y1772	Y1770	Y1768	Y1766	Y1764	Y1762	Y1760	Y1758	Y1756	Y1754	Y1752	Y1750	Y1748	Y1746	Y1744	Y1742	Y1740	Y1738	Y1736	Y1734	Y1732	Y1730	Y1728	Y1726
108						?S1																									
109																															
110																															
111					LS106																										
112					MO3																										
113																															
114							LO8																								
115																															
42																															
43																															
44																															
45				?O1																											
46																															
47			?MO2																												
48																															
49																															
50																															
51																															
52																															
53																															
54																															
61																															
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64																															
139																															
140																															
56																															
57																															
58			?E1																												
59																															
60			?MS1																											?MO2	
124							LO4																								
125									LO7																						
126					LO7																										
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142																															
143																								NS104							
127									LS109																						
128									LO9																						
129									LS209																	?O1					
69																															
77																															
78																															
79														LO6																	
80						?S1			MS2																?ME3						
70									?O1																?LO2						
74																															
75																								MO2							
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85																															
65																															
66																															
67																															
68									?LO1																						
71									?MS102																						
72									?LO1																						

B-3

* ALL II SUSPE																					
PLOT	LANDFRM 3	SURF GEOL	PLT POS 1	PLT POS2	INTERVAL TO 1992	1ST DATE	*INTERVAL	2ND DATE	INTERVAL	3RD DATE	INTERVAL	4TH DATE	INTERVAL	5TH DATE	INTERVAL	6TH DATE	INTERVAL	7TH DATE	INTERVAL	8TH DATE	INTERVAL
44	UD	MX-AS-QU	BK	RB	130	1862	30	1832													
45	UD	MX-AS-QU	RI	WI	96	1896	40	1858	76	1780											
46	UD	MX-AS-QU	MS	MS	116	1876	44	1832													
47	DI	MX-AS-QU	MS	US	134	1858	30	1828	46	1782											
48	UD	MX-AS-QU	MS	US	116	1876	18	1858													
49	UD	MX-AS-QU	RI	WI	116	1876	12	1864	12	1852	38	1814									
50	UD	MX-AS-QU	BK	RB	138	1854															
51	DI	MX-AS-QU	MS	LS	106	1886	38	1848													
52	UD	MX-AS-QU	RI	NW	56	1936	32	1904													
53	DI	MX-AS-QU	BK	RB	78	1914	16	1898	30	1868	36	1832									
54	UD	MX-AS-QU	BK	RB	86	1906	34	1872													
61	DI	MX-AS-QU	MS	US	124	1868	12	1856	42	1814											
62	UD	MX-AS-QU	MS	LS	136	1856	36	1820													
63	UD	MX-AS-QU	MS	MS	138	1856	46	1810													
64	UD	MX-AS-QU	MS	MS	102	1890	34	1856	38	1818											
139	DI	MX-AS-QU	MS	MS	80	1912	52	1860	38	1822											
140	DI	MX-AS-QU	BK	RB	84	1908	24	1884	20	1864	38	1826									
56	UD	MX-AS-QU	SH	WI	50	1942	16	1926	24	1902	14	1888	24	1864	14	1850	28	1822			
57	DI	MX-AS-QU	BK	RB	126	1868															
58	DI	MX-AS-QU	MS	MS	50	1942	44	1898	34	1864	44	1820	40	1780							
59	DI	MX-AS-QU	MS	US	72	1920	54	1866	54	1812											
60	UD	MX-AS-QU	WV	FP	76	1916	136	1780	52	1728	56	1672	80	1592							
124	UD	MX-AS-QU	MS	MS	144	1848	32	1816	44	1772											
125	UD	MX-AS-QU	MS	MS	140	1852	82	1770													
126	DI	MX-AS-QU	MS	MS	160	1832	56	1776													
130	UD	MX-AS-QU	MS	MS	110	1882	44	1838													
131	DI	MX-AS-QU	BK	RB	96	1896	32	1864	26	1838											
132	UD	MX-AS-QU	MS	LS	154	1838															
133	UD	MX-AS-QU	MS	LS	84	1908	26	1882	22	1860	30	1830									
141	UD	MX-AS-QU	MS	US	54	1938	38	1900	18	1882	24	1858	32	1828							
142	UD	MX-AS-QU	MS	MS	116	1876	136	1740	198	1542											
143	UD	MX-AS-QU	BK	RB	82	1910	50	1860	32	1828	126	1702	44	1658	78	1580	38	1542			
127	UD	MX-AS-QU	NV	LE	222	1770	228	1542													
128	UD	MX-AS-QU	SH	NW	222	1770															
129	UD	MX-AS-QU	MS	MS	170	1822	52	1770			52	1686	62	1624	88	1536					
68	UD	MX-AS-QU	BK	RB	66	1926	102	1824	36	1788											
77	UD	MX-AS-QU	BK	RB	104	1888	22	1866	76	1790											
78	UD	MX-AS-QU	MS	MS	84	1908	18	1890	20	1870	30	1840	52	1788							
79	UD	MX-AS-QU	BK	RB	93	1899	29	1870	38	1832	34	1798	38	1760							
80	UD	MX-AS-QU	AF	US	92	1900	52	1848	42	1806	30	1776	6	1770	30	1740	166	1574	34	1540	
70	UD	MX-AS-QU	MS	US	78	1914	54	1860	56	1804	66	1738									
74	DI	MX-AS-QU	MS	MS	94	1898	230	1668	108	1560											
75	UD	MX-AS-QU	MS	US	134	1858	54	1804	60	1744	48	1696									
76	UD	MX-AS-QU	MS	US	298	1694	38	1856	122	1534											
83	UD	MX-AS-QU	MS	US	186	1806	108	1698	44	1654											
84	UD	MX-AS-QU	SH	WI	110	1882	70	1812	74	1738	84	1654	84	1570							
85	UD	MX-AS-QU	SH	WI	61	1931															
65	UD	MX-AS-QU	RI	NW	60	1932	12	1920	118	1802	68	1734	148	1588							
66	UD	MX-AS-QU	MS	US	60	1932	22	1910	78	1832	28	1804									
67	UD	MX-AS-QU	MS	US	82	1910	106	1804	86	1718	54	1664									
68	UD	MX-AS-QU	MS	US	62	1930	20	1910	120	1790	18	1772									
71	UD	MX-AS-QU	MS	MS	60	1932	102	1830	42	1788	16	1772	12	1760							
72	UD	MX-AS-QU	MS	US	60	1932	142	1790	18	1772											
73	UD	MX-AS-QU	MS	US	88	1904	80	1824	32	1792											
122	UD	MX-AS-QU	MV	AF	68	1924	322	1802													
123	UD	MX-AS-QU	BK	RB	68	1924	258	1666	64	1602											
134	UD	MX-AS-QU	MS	LS	198	1794															
136	UD	MX-AS-QU	MS	MS	122	1870	54	1816	24	1792	8	1784	30	1754	100	1654	104	1550			
135	DI	MX-AS-QU	BK	RB	74	1918	104	1814													
137	UD	MX-AS-QU	MS	MS	82	1910	132	1778													
138	UD	MX-AS-QU	MS	US	78	1914															
86	DI	MX-AS-QU	MS	LS	138	1854	36	1818	42	1776											
87	DI	MX-AS-QU	BK	RB	86	1906	90	1818													
89	UD	MX-AS-QU	RI	NW	88	1904	32	1872	6	1866	14	1852	26	1826							
90	DI	MX-AS-QU	MS	US	174	1818	40	1778													
91	UD	MX-AS-QU	MS	US	104	1888	14	1874	16	1858	36	1822									
92	DI	MX-AS-QU	MS	MS	94	1898	42	1856	28	1828											
93	DI	MX-AS-QU	BK	RB	168	1824															
94	UD	MX-AS-QU	MV	FP	174	1818															

ART ZACK

CD'A FIRE INTERVALS

* ALL II					STAND LEVEL DATA -- ALL DATA			STAND DATA -- PRE 1880 PERIOD		PRE 1760 PERIOD	WATERSHED & AREA AVERAGES		*MEAN
SUSPE					*MEAN STAND LETHAL	MEAN STAND FIRE	PRE 1880 MEAN STAND	PRE 1880 MEAN STAND	PRE 1760 MEAN STAND			VALUE	
PLOT	9TH DATE	INTERVAL	10TH DATE	INTERVAL	11TH DATE	FIRE INTERVAL	RETURN INTERVAL	LETHAL FIRE INTERVAL	FIRE RETURN INTERVAL	FIRE RETURN INTERVAL	ITEM MEASURED	YEARS	
44						160.0	80.0		30.0				
45						136.0	70.7		58.0				
46						160.0	80.0		44.0				
47						164.0	70.0		38.0				
48						134.0	67.0		18.0				
49						178.0	44.5		20.7				
50						138.0	138.0						
51						144.0	72.0		38.0				
52						88.0	44.0						
53						160.0	40.0		33.0				
54						120.0	60.0		34.0				
61						178.0	59.3		27.0				
62						172.0	86.0		36.0				
63						182.0	91.0		46.0		YELLOWDOG MEAN STAND LETHAL FIRE RETURN INTERVAL	152.5	
64						174.0	58.0		36.0		YELLOWDOG MEAN FIRE RETURN INTERVAL -- ALL FIRES	67.8	
139						132.0	56.7		45.0		YELLOWDOG PRE 1880 MEAN STAND LETHAL FIRE RETURN INTERVAL		
140						166.0	41.5		29.0		YELLOWDOG PRE 1880 MEAN FIRE RETURN INTERVAL -- ALL FIRES	34.7	
56						170.0	24.3		22.0				
57						126.0	126.0						
58						172.0	42.4		39.3				
59						180.0	60.0		54.0				
60						400.0	80.0		81.0	62.7			
124						220.0	73.3		38.0				
125						222.0	111.0		82.0				
126						216.0	108.0		56.0				
130						154.0	77.0		44.0				
131						154.0	51.3		29.0				
132						154.0	154.0						
133						162.0	40.5		26.0				
141						166.0	33.2		28.0				
142						450.0	150.0		167.0	167.0			
143						450.0	64.3		61.3	71.5	N. FK CD'A MEAN STAND LETHAL FIRE RETURN INTERVAL	226.2	
127						225.0	225.0	228.0	169.0	228.0	N. FK CD'A MEAN FIRE RETURN INTERVAL -- ALL FIRES	95.5	
128						222.0	222.0		110.0		N. FK CD'A PRE 1880 MEAN STAND LETHAL FIRE RETURN INTERVAL	231.0	
129						228.0	76.0	234.0	57.3	58.5	N. FK CD'A PRE 1880 MEAN FIRE RETURN INTERVAL -- ALL FIRES	66.5	
69						204.0	68.0		46.0				
77						202.0	67.3		49.0				
78						204.0	40.8		34.0				
79						232.0	46.4		34.8				
80						452.0	56.5		51.4	76.7			
70						254.0	63.5		58.7	66.0			
74						169.0	144.0	169.0	169.0	169.0			
75						296.0	74.0		54.0	54.0			
76						229.0	152.7	122.0	115.3	75.3			
83						338.0	112.7		75.3	76.0			
84						338.0	84.4		78.0	80.7			
85						61.0	61.0						
65						203.0	81.2	334.0	111.3	108.0			
66						188.0	47.0		53.0				
67						274.0	82.0		82.0	70.0			
68						110.0	55.0	158.0	69.0		SHOSHONE MEAN STAND LETHAL FIRE RETURN INTERVAL	226.1	
71						232.0	46.4		43.0		SHOSHONE MEAN FIRE RETURN INTERVAL -- ALL FIRES	74.9	
72						110.0	73.3	160.0	80.0		SHOSHONE PRE 1880 MEAN STAND LETHAL FIRE RETURN INTERVAL	188.6	
73						200.0	66.7		56.0		SHOSHONE PRE 1880 MEAN FIRE RETURN INTERVAL -- ALL FIRES	70.0	
122						195.0	195.0	322.0	322.0	322.0			
123						130.0	130.0	161.0	161.0	161.0			
134						198.0	198.0		198.0				
136						221.0	63.1		53.3	78.0	EAGLE CRK MEAN STAND LETHAL FIRE RETURN INTERVAL	156.4	
135						178.0	89.0		104.0		EAGLE CRK MEAN FIRE RETURN INTERVAL -- ALL FIRES	107.0	
137						107.0	107.0	132.0	132.0		EAGLE CRK PRE 1880 MEAN STAND LETHAL FIRE RETURN INTERVAL		
138						78.0	78.0				EAGLE CRK PRE 1880 MEAN FIRE RETURN INTERVAL -- ALL FIRES	121.8	
86						174.0	72.0		39.0				
87						176.0	88.0		90.0				
89						166.0	33.2		19.5				
90						214.0	107.0		51.0				
91						170.0	42.5		22.0				
92						164.0	54.7		35.0				
93						168.0	168.0		56.0				
94						174.0	174.0		62.0				